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QUATERNARY STRATIGRAPHY OF THE DARLING RIVER NEAR TILPA, NEW SOUTH WALES

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ABSTRACT; The Moomba to Sydney gas pipeline trench exposed a sequence of late Quaternary landforms and sediments where it crossed the Darling River floodplain in western New South Wales. Stratigraphic sections and radiocarbon analyses along 20 km of the pipeline demonstrate a sequence of fluvial and aeolian phases that are comparable to events of similar age elsewhere in southern Australia.

Following alluviation about 30,000B.P., an episode of intensified dune building dated to between about 20,000 to 16,000 B.P. spanned the glacial maximum. Simultaneously with this phase the Darling River, draining summer rainfall areas to the north, entered a phase characterized by large meander wavelength channels subject to rapid lateral migration. In so doing it produced morphologic characteristics similar to those ancestral streams of glacial age in the Goulburn River in northern Victoria. This similarity in the behaviour of channels draining summer and winter rainfall catchments respectively demonstrates the widespread ability of glacial age hydrologic changes to produce similar morphologic and depositional expressions through widely differing climatic and physiographic regions.

The mechanism of anabranch formation in this region is related to the hydrologic changes that accompanied the end of the glacial age hydrologic environments and the initiation of suspended load Holocene channels. A similar mechanism probably explains the relationships between anabranches and modern channels downstream.

INTRODUCTION

The excavation in early 1975 of the gas pipeline trench linking Sydney, New South Wales, and Moomba in northern South Australia offered a rare opportunity to examine and document geological and soil structures over a large area of western New South Wales. In this way surface forms could be related to sub-surface sediments and structure. One such area of interest was that where the pipeline crossed the Darling River with its associated array of alluvial and aeolian landforms. In this paper we are concerned to describe the major units recognized and, by dating them, to provide new information on the chronology and environmental evolution of this region from which little detailed information was previously available.

THE AREA

Trending northwest from the Barrier highway, the pipeline intersected the Darling some 10 km downstream from Tilpa (Fig. 1). The area north and south of the Darling is one of very low relief broken only by dune ridges rising to about 12 m above the grey clay alluvial plain. Into this plain the channels of Acres Billabong, the Darling Anabranch and the Darling channel itself are cut.

The region is one of low rainfall and high evaporation. On the regional maps of the Commonwealth Bureau of Meteorology it lies near the 250 mm isohyet, with pan evaporation averaging more than 2000 mm per year. Thus the area lies on the arid margin of the semi-arid zone of south-eastern Australia.

DRAINAGE

The Darling River, draining a large area of northwestern New South Wales and southern Queensland, receives most of its waters from summer monsoonal rains, although locally the Tilpa area receives approximately 40% of its rainfall from winter westerly circulation. Acres Billabong, now a largely inactive channel except

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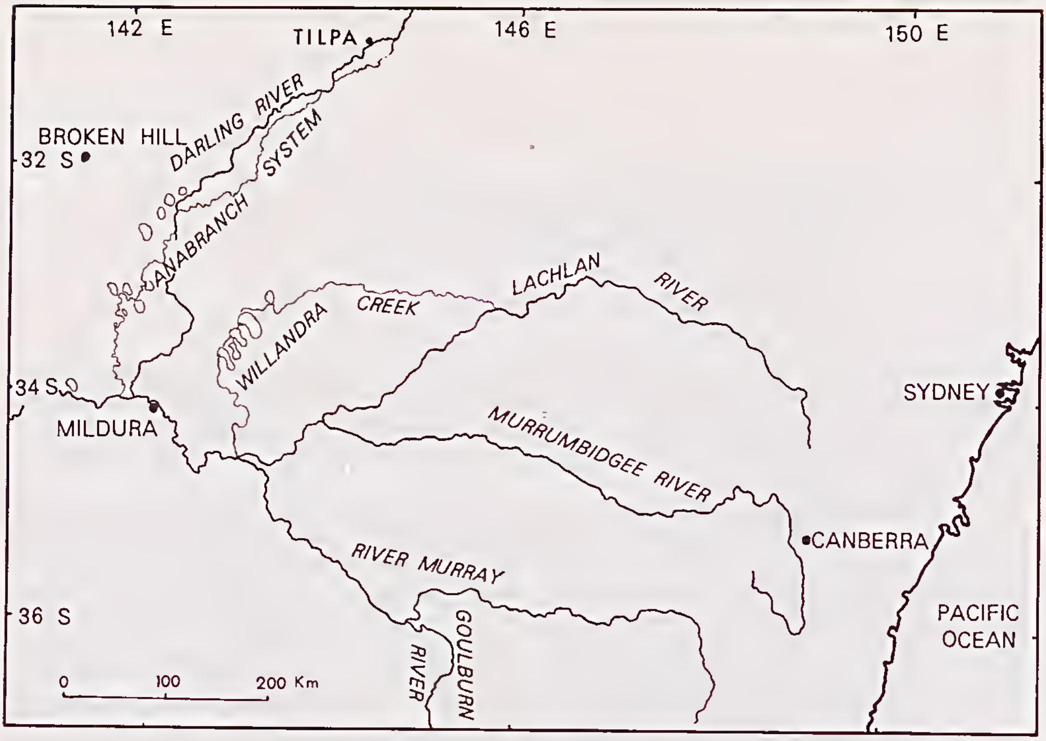

FIG. 1 — Rivers of southeastern Australia illustrating some localities discussed in text.

during high stage flows, represents an ancestral course of the Darling River. The present river channel breaks away from its ancestor near Tilpa, and at the pipeline crossing the ancient and modern channels are 14 km apart (Fig. 2). In rejoining 12 km downstream, Acres Billabong represents a typical anabranch.

Not only are these older and younger systems separated spatially, but perhaps more significantly they possess markedly different morphological characteristics. The Darling flows in a narrow meander belt with its channel retaining small meander wavelengths. By contrast the scroll bars and final channel form of the ancestral stream

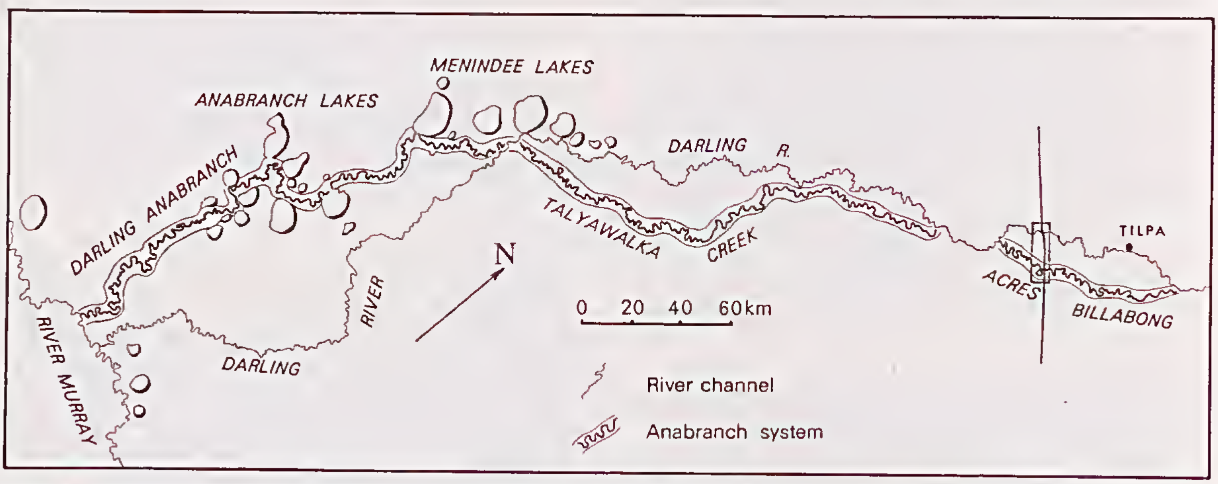

FIG. 2 — Diagram showing location of gas pipeline crossing Darling River and Acres Billabong. Downstream to the River Murray the modern channel has broken out of the anabranch systems which represent the ancestral course of the Darling dated in the pipeline section to between 20,000 and 11,000 B.P. Note association of lakes with the ancestral course. For inset see Fig. 3.

portray a highly sinuous course in a wide meander belt with characteristically large meander wavelengths and large radii of curvature.

The pipeline intersected three additional landform units. Throughout the region, rather irregular red quartz dunes maintain west to easterly trends reflecting the dominance of westerly winds. They often rise through extensive grey alluvial plains as though partly submerged by them. In the centre of the region is a small dry lake basin with multiple grey lunette ridges on its eastern side.

Aims, Organization and Methods

In examining data from this region Stockton and Walker mapped stratigraphic sections and collected radiocarbon dating material from the area north of the river where the trench intersected a red dune complex before dropping down onto a grey calcareous plain some 3 km from the channel. Within this region they identified soil-sedimentary units and plotted their lateral continuity. In the southern sector Stockton and Bowler mapped the region extending to Acres Billabong and collected ^{14}C samples from the ancestral pointbar sediments.

Time for detailed field examination was necessarily brief as only a couple of days lapsed between the opening of the trench and the laying of the pipe. In this report we provide a brief description of the aeolian and alluvial units represented, assess the value of the ^{14}C chronology obtained, and place some aspects of the hydrologic changes identified into a regional perspective. The landform map (Fig. 3) has been constructed from aerial photographs whilst detailed survey levels along the trench have been used to plot topographic and stratigraphic sections.

Radiocarbon analyses were carried out in the University of Sydney for Stockton and Walker (code SUA) and in the Australian National University for Bowler (code ANU).

IDENTIFICATION AND DESCRIPTION OF UNITS

The general stratigraphic cross-section (Fig. 4) displays the relationships between the main landform units and the sediments of which they are composed. In this sequence, ridges of red quartz sand protrude through a cover of grey clay. This latter alluvial component is dominantly younger than the core of quartz dunes. North of Acres Billabong the alluvium possesses secondary carbonate, in a soil profile with moderate to well developed prismatic jointing developed in clays with angular to blocky structure. This degree of pedality differentiates grey alluvial plain in the centre of Fig. 3 from those other alluvial bodies more closely associated with present drainage lines. Thus in the area extending 500 m north of Acres Billabong, grey sandy clays, often with sandy laminae dipping to the south, represent pointbar deposits of the ancestral stream; almost no profile differentiation was evident in such deposits. Clays lying to the north and south of the Darling River are considerably darker grey in colour than the older alluvial deposits, and they too lack horizon differentiation consistent with active overbank deposition in this flood-prone region.

North of the river, Stockton and Walker mapped an horizon of brownish red sandy clay loam to heavy clay that passes under both the main body of the sand dunes and under the Darling floodplain clays (Fig. 4). Charcoal from within this unit located 2 m below the floodplain and 0.8 km northwest of the Darling provided the oldest ^{14}C date available, 35,450 $\pm$ 1,600 B.P. From the configuration of this unit, which rises and forms the core underlying younger dunes, it is tentatively identified as an early aeolian deposit.

On the most northerly sector of the cross-section the basal red unit passes beneath grey silty clay representing older alluvium on which a grey calcareous paleosol has formed. Carbonate nodules from within this unit provide a ^{14}C age of 19,600 $\pm$ 460 B.P.

The dunes that form the most prominent ridges in the landscape have a deep red calcareous soil with nodular to earthy carbonate often forming zones up to 0.7 m thick. In its upper part the profile consists of non-calcareous red brown sand (2.5 YR 4/8) about 40 cm thick on crestal sites. From within the A-horizon sands carbon, perhaps representing burnt root remains, dated to 8,035 and 4,420 B.P. (Table 1).

In the section through the crest of the largest sand dune 2.5 km southeast of the Darling the strong red colours pass down through a Bca horizon to paler orange to yellow weakly calcareous quartz sands. This downward gradation in profile colouration indicates *in situ* rubefaction by pedogenic processes. This might further suggest that the origin of the sands lay in their derivation from washed channel sands rather than from the reworking of older aeolian materials. The red calcareous dune sands pass in a southerly direction under grey alluvial clay loam, which in turn grades laterally into lacustrine and lunette grey calcareous clayey sands.

The aeolian units are overlain in the centre of the region by a thin layer of well bedded quartz sands

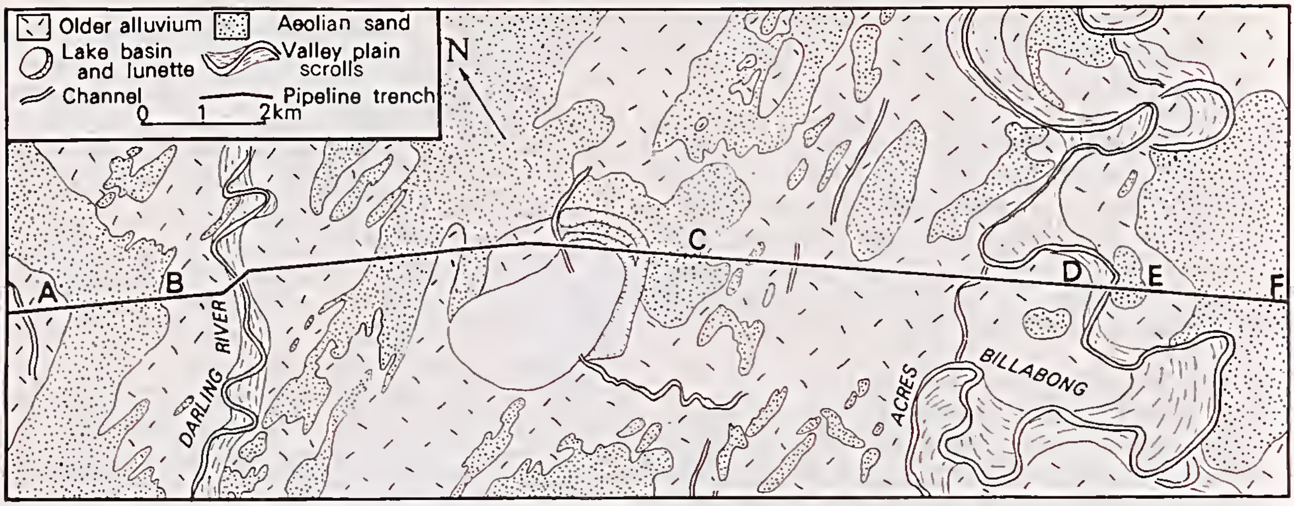

FIG. 3 — Map of landform units in the area intersected by pipeline trench across the Darling River near Tilpa.

usually less than 50 cm thick. The preservation of bedding indicates its recent origin as a windblown layer. Two charcoal dates collected by Stockton and Walker from 8 and 28 cm below this well developed bedded zone provide ages of 245 and 335 yr B.P. respectively (Table 1). These possibly represent roots intruding into the underlying layer. The age of the thin bedded unit is probably younger than the ^{14}C ages. It may relate to post-European disturbance by grazing.

Alluvial Chronology

Two main bodies of alluvium have been differentiated on Fig. 3: an older unit identified on the basis of its calcareous soil, and younger alluvium in which little or no pedogenic development testifies to its relatively recent origin. The younger alluvium is directly associated with both active and inactive channels.

For some 500 m the trench near Acres Billabong exposed sediment deposited by the southerly migration of that channel (Fig. 4). Here the alluvial strip associated with the ancestral stream is set into older grey calcareous alluvial clay. The contact exposed in the wall of the trench dipped to the south at 15°, representing the stratigraphic disconformity between these two alluvial units. Expression of the disconformity at the contact was a subtle one, depending more on the loss of primary bedding and the development of diagnostic soil characteristics in the older body. In the upper 50 cm a blanket cover of grey clays representing overbank deposits from the active phase of Acres Billabong masks the stratigraphic discontinuity which therefore has no

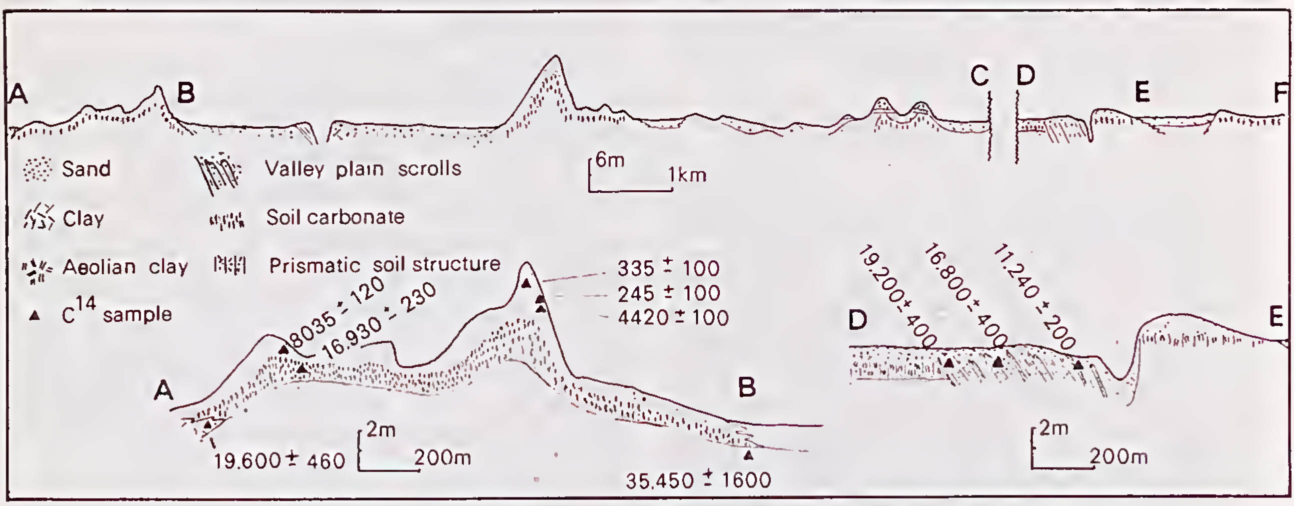

FIG. 4 — Stratigraphic cross sections through the area shown in Fig. 3.

TABLE 1
RADIOCARBON DATES FROM GAS PIPELINE TRENCH IN SECTIONS NORTH AND SOUTH OF DARLING RIVER

	Lab. No.	^{14}*C Age*	*Material Dated*
Sequence Northwest of Darling River Collected by E.S. & M.J.W.	SUA-448	245 ± 100	Charcoal from 20 cm below surface, 8 cm below base of uppermost layered aeolian sand located 1.15 km NW. of Darling River.
	SUA-447	335 ± 100	Charcoal from 40 cm in section 1.35 km NW. of Darling River.
	SUA-450	4,420 ± 100	Charcoal from 100 cm below surface in base of zone interpreted as A-horizon of red calcareous soil on dune 1.15 km NW. of river.
	SUA-440	8,035 ± 120	Charcoal from position stratigraphically equivalent to SUA-450 in section 1.55 NW. of river.
	SUA-446	16,930 ± 230	Top of calcrete crust in red calcareous paleosol on dune (Fig. 4A).
	SUA-438	19,600 ± 460	Calcrete developed in grey alluvium at approx. 1.5 m depth, 1.5 km NW. of river.
	SUA-435	35,450 ± 1,600	Charcoal from 2 m below floodplain 0.8 km NW. of river from within basal reddish brown sandy clay of probable aeolian origin.
Acres Billabong Sequence Collected by J.M.B. & E.S.	ANU-1982	11,240 ± 200	Charcoal pellets from burnt surface dipping 14° to SE. within pointbar clayey silts 100 m NW. of Acres Billabong.
	ANU-1993	16,800 ± 400	Charcoal from layer f reddish oxidized clayey silts indicating *in situ* burning on bedding plane dipping 15° SE., 390 m W. of Acres Billabong.
	ANU-1984	19,200 ± 400	Charcoal in layered zone 2 cm thick dipping to SE. in grey silty pointbar deposits 530 m NW. of Acres Billabong and 6 m from discomformable contact with older alluvium.

clear surface expression. However at depth in the lower part of the trench the disconformity was clearly apparent.

From 6 m south of the disconformity and 540 m north of the channel, charcoal from a southerly dipping band within sediments of Acres Billabong phase provided a ^{14}C date of 19,200 ± 400 B.P. Since the disconformity here marks the first stage in the development of Acres channel, this event must be placed close to 20,000 B.P.

Charcoal samples from similarly dipping bands located 390 m and 100 m north of the channel provide ^{14}C ages of 16,800 ± 400 and 11,240 ± 120 respectively, as in Table 1.

Expressed in terms of rates of pointbar accretion (Fig. 5) the dates indicate an almost linear rate of change. The position of the sample dated to 11,200 B.P. from within the segment slightly inset below the main level of the pointbar phase (Fig. 4) suggests that a change in the depositional nature of Acres channel regime occurred somewhat before that time.

DISCUSSION

AEOLIAN STRATIGRAPHY

The oldest date in the sequence (SUA-435) provides a maximum age for the development of the older alluvium. Moreover the charcoal was within what we believe to be ancient aeolian materials; this early dune building phase is older than 35,000 B.P.

Dates from soil carbonate horizons provide only approximate ages for deposition and soil formation in these environments. Whilst Bowler and Polach (1971) regard them as usually indicating minimum ages Williams and Polach (1971) have interpreted them in arid regions as indicating ages close to initial soil formation. However, bearing this uncertainty in mind, the samples SUA-446 and SUA-438 bracket the deposition of the main aeolian unit, provided contamination of the lower sample (438) through the aeolian sand can be excluded. Since we can not eliminate this possibility, the evidence may be interpreted to

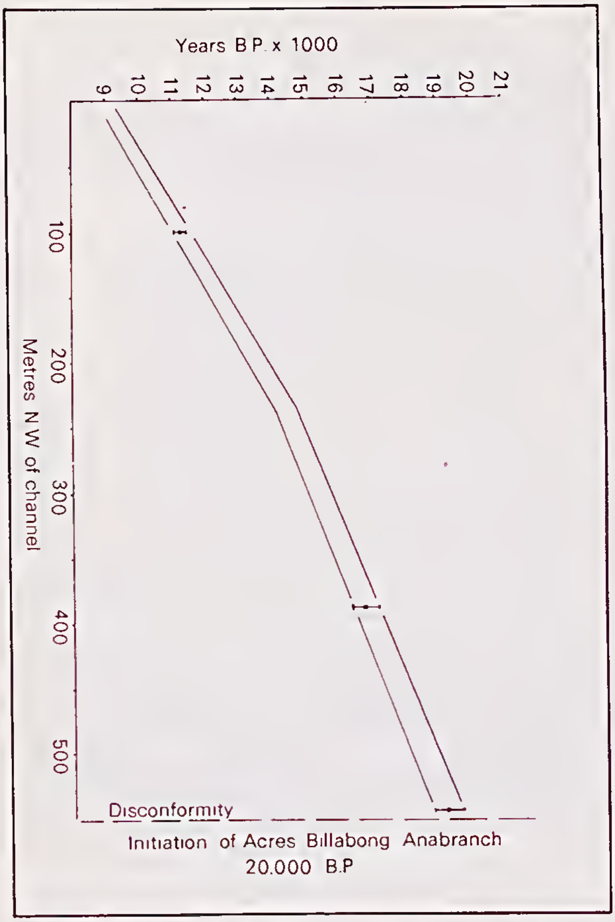

FIG. 5 — Curve envelope showing the rate of lateral migration of Acres Channel since its inception about 20,000 B.P. until its abandonment about 10,000 B.P.

indicate alluviation between 36,000 until sometime before about 20,000 B.P. Pedogenesis followed, perhaps synchronously with aeolian activity.

In considering the age of the next aeolian event, account must be taken of the limitations of carbonate dates. The process of attaining equilibrium between parent carbonate and soil atmosphere during the formation of pedogenic nodules may not have gone to completion. The true age of the soil calcrete may even be somewhat younger than the ^{14}C ages suggest. However, for the upper sample (SUA-446) at least, in view of the age of the underlying unit, it could not be much older than 17,000 B.P. Conversely, the age of pedogenesis indicated by the lower carbonate date (SUA-438), whilst it may be somewhat older than 19,600, certainly could not be significantly younger. Therefore, the age of aeolian deposition is bracketed between about 20,000 until soon after 16,000 B.P.

The two dates from aeolian units higher in the sequence (SUA-449 & SUA-450) are open to alternative interpretations. Coming from within the A-horizon of the red calcareous soil, they probably represent burnt tree remains that grew in that soil. As such they indicate relative stability until at least 4,000 B.P.

The main aeolian unit is that which constitutes the body of the dunes. Its age is in good agreement with the last phase of major aeolian activity postulated from evidence further south, as having occurred between 25,000 and 16,000 B.P. with the peak development about 17,000 B.P. (Bowler 1970). Thus it appears that events of maximum glacial age were expressed here also by intensified aeolian activity simultaneously with that which seems to have affected the entire region of southern Australia.

Some 130 km to the south of Tilpa, a younger episode of dune building has been recorded by Wasson (1976) in the Belarabon area. However this event, which lies between 3,000 and 600 B.P., does not appear to have any distinct expression in the region studied. This may be due more to a preceding phase of alluvial deposition in the Belarabon Ranges as Wasson suggested, and the relative absence of such reactivation on the Darling floodplain.

ALLUVIAL STRATIGRAPHY

1. *Chronologic sequence.* The ^{14}C chronology suggests the following sequence of events in the alluvial history of the region. Between 36,000 and about 20,000 B.P. active floodplain deposition was taking place, particularly in the area north of the Darling. Traces of an ancient channel lying just on the northern edge but mainly outside the mapped area in Fig. 3 probably represent the course of the Darling at that time.

About 20,000 B.P. avulsion and channel diversion occurred with the development of the first phase of Acres Billabong. Maintaining its characteristically large meander scroll pattern, it continued to widen its belt in a sinuous course for some 8-9,000 years. Soon after 11,000 B.P., a second avulsion took place with the development of the present course of the Darling north of Acres channel, which then became progressively abandoned.

2. *Significance of Acres Billabong.* The contrast between the morphology of the modern channel and that of Acres Billabong points towards major changes in the hydrologic regime. Elsewhere in southeastern Australia a similar contrasting rela-

TABLE 2
MORPHOLOGIC PARAMETERS OF DARLING RIVER AND ACRES BILLABONG AS REPRESENTED BY TRACE OF CHANNELS AND SCROLLS ON FIG. 3.
Amplitude, curvature and wavelength measurements in metres with variation to one standard deviation. Measurements of the Goulburn River and its glacial age ancestral course from Bowler (1978).

CHANNEL SYSTEM	DARLING	ACRES	GOULBURN	KOTUPNA
Sinuosity	1.45	2.35	1.58	1.23-2.02
Meander amplitude (m)	575 ± 150	1,620 ± 250	730	1,340
Radius of curvature of scrolls (m)	297 ± 94	670 ± 210	NA	NA
Meander wavelength (m)	1,050 ± 164	2,190 ± 260	550	3,000

tionship exists between modern and ancestral channels. On the Goulburn River in northern Victoria, channels of an ancestral phase (the *Kotupna* of Bowler 1978) possessed meander features many times larger than those of the modern Goulburn. But most significantly the ages established here for the active migration phase of Acres Billabong, 20,000 to 11,000 B.P., are similar to the ages of channels with comparable morphology in the Goulburn valley. There the ancestral features were active from at least 25,000 until about 13,000 B.P.

When compared in detail (Table 2), the relationships between Goulburn-Darling palaeochannels and their modern successors exhibit a number of striking similarities. A ratio of ancient to modern meander belt widths in the Goulburn of 2:1 is similar to that of Acres Billabong compared with the Darling meander belt. In both areas, meander belt widths were developed by lateral channel migration. The pipeline trench intersected Acres Billabong near a nodal point of minimum meander enlargement. However scroll bars on large meanders east and west of the section (Fig. 3) indicate channel migration of 1.5 to 1.8 km. Over the period 20,000 to 11,000 B.P., this is equivalent to a migration rate of 17 to 20 cm per year, a figure that corresponds almost exactly with the channel migration rate established for the Kotupna ancestral phase on the Goulburn (Bowler 1978).

In one feature palaeochannels of the Darling and Goulburn are different from each other. In Acres Billabong, deposition and scroll bar development indicate bank erosion on the outside edge of meanders producing a progressive lateral enlargement, increasing sinuosity but producing little down-valley migration. By comparison, channels of the Kotupna phase migrated down-valley leaving a train of meander scrolls in a broad belt of alluvium. In Acres Billabong there was a progressive decrease in the channel bed gradient whilst in the Kotupna system the broad meander belt, once established, migrated downstream preserving constant gradient of the channel bed. The mechanisms responsible for this different behaviour are not understood.

The similarity in form and the correspondence in age of these large meandering palaeochannels from catchments which experienced entirely different climatic regimes throughout the period of the maximum global refrigeration from at least 20,000 to 13,000 B.P. sheds new light on our understanding of the underlying causes. In the Goulburn, draining the cold highlands of southeastern Australia with dominant winter rainfall, the explanation offered by Bowler (1978) for the hydrologic changes involved a combination of increased discharges in ancient channels associated with bed load yield higher than in the modern regime. The higher quantity of sands in glacial age channels could be explained by two factors. Firstly, upland slopes, denuded of woodland vegetation by periglacial activity, would have contributed large quantities of detritus into headwater streams. Secondly, the rapid migration indicated by radiocarbon ages in Kotupna palaeochannels involves bank erosion, sorting, and redeposition of sediment loads much in excess of those of the modern stream. These two processes would have combined to produce much more sand than in the suspended load channels of today.

In the Darling catchment, the influence of periglacial activity must be ruled out. The factors common to both Goulburn and Darling streams that contributed to the similarity in form and behaviour of palaeochannels may be summarized as follows:

1. Channel-forming discharges of glacial age were probably considerably in excess of those in the past 10,000 years. In both Queensland and the Victorian highlands reduced glacial age tem-

peratures would have contributed to a drastic reduction in evapo-transpiration with a consequent increase in availability of surface water. In catchments affected by loss of woodland vegetation this effect would be amplified by faster runoff. Whilst riparian woodlands were absent from the Murray-Goulburn systems at this time (Bowler 1978) the vegetation association along the Darling channels is not known.

2. In addition to increased discharge, the evidence suggests that palaeochannels of both systems contained coarser bedloads than their modern equivalents. In Acres Billabong, the persistence of sandy lenses across scroll bar sections (Fig. 4) supports this view. As established by Schumm (1960) this factor will contribute significantly towards explaining larger channel morphology. The synchroneity reaffirmed between the ages of the large meander phase and active dune building about 17,000 B.P. means that much sand would have been blown into the channel of the Acres system. Such sand, possibly derived from earlier phases of alluviation, would have helped change the bedload regime, at least in the Darling area where dunes were active at the time. However, on the Goulburn the evidence suggests that sands were blowing out of, but not into, the palaeochannels.

3. The rapid meander migration rates established in both systems point to bank failure occurring at rates much higher than today. In addition to the possible absence of channel margin woodland, two additional factors may have been operating in both regions. Firstly, bank failure is enhanced by rapid draw-down of the level of water in the channel relative to the level of saturated pore water in the banks. Low bank cohesion combined with high pore water pressure results in increased bank failure. The faster the flood wave falls, the more bank failure will occur. Thus the more peaked the flood wave, the more rapid channel and meander migration will result.

Peaked flood waves will be favoured by conditions of enhanced seasonality. Such claims have been made for glacial age conditions in this part of southeastern Australia (Bowler *et al.* 1976). But to explain features common to both the Darling and Goulburn regions this would require greatly increased seasonal contrast in the summer rainfall on one hand and in winter precipitation on the other. However, since the high stage Goulburn discharge would be controlled by late spring-summer thaw of highland snowfields, the result would be increased summer flow from the winter catchments which would then coincide with high stage summer flow from the monsoon region. In this respect the seasonal high stage flows from both streams would have been much more closely timed than they are today.

The second factor that may have played a major role in enhanced bank failure concerns the regional and local watertable. The presence of regionally high watertables will have an effect similar to that described for rapid river draw-down following the passage of a flood wave. A fall in river level in an area of high watertables will result in a sustained level of pore pressure inducing more rapid bank failure than if watertables are low as in the present regime. The effect of increased return flow through the banks would be much the same as that described for the passage of a peaked flood wave.

The study of lake basins throughout a large area of northern Victoria and southwestern New South Wales has demonstrated the widespread and simultaneous construction of saline clay-rich lunettes in the interval between 20,000 and 15,000 B.P. (Bowler 1976). Their construction requires the presence of saline watertables at or near the surface over extensive regions. Under such conditions, low stage flows in rivers would be accompanied by high pressures on the banks inducing active bank failure. The presence of a small lake in the central part of the pipeline section south of the Darling with an ancient calcareous lunette whose age is apparently similar to those dated elsewhere, provides strong supporting evidence that high watertables here, as in the Goulburn Valley, contributed to rapid bank failure and accelerated meander migration.

Relevance to Darling Anabranches

The features described here bear on our understanding of the regional geomorphology of the Darling River. One of the anomalous features of Australian fluvial geomorphology is the common occurrence of complex anabranching channels on the inland plains. Indeed the best known example, the Anabranch of the Darling, occurs only 250 km downstream from the Tilpa pipeline section (Fig. 2). The ages and causes of anabranch development hitherto unexplained may be reviewed in the light of the Acres Billabong evidence.

In the Darling system downstream from Tilpa palaeochannels occur that possess morphologic characteristics identical with those described here from Acres Billabong (Fig. 2). Thus downstream from Acres Billabong, Talyawalka Creek follows one such diversion south of the Darling; in its meander belt ancient scroll bars preserve patterns identical with those of Acres Billabong. These cross the Darling near Menindee and continue west towards Lake Tandou in the course now occupied by Redbank Channel. Downstream this system is known as the Darling Anabranch. Thus not only do the palaeochannels show similar morphology to that of Acres Billabong but its history of avulsion and anabranch formation under an ancient regime may be common to all such examples in this locality. It is significant that the modern Darling tends to avoid the course of the ancestral channels in the tract extending from Tilpa downstream to the River Murray junction.

With the evolution of the large meander regime characterized by Acres Billabong, the increased sinuosity and progressive reduction in channel gradient eventually resulted in a major loss of efficiency. Under conditions of diminishing discharge such as may have existed in the transition from glacial age to Holocene regimes (from about 14,000 to 10,000 B.P.) these systems were sufficient to carry the water load. About 10,000 B.P. the evidence from southwestern Victoria (Dodson 1974, Bowler *et al.* 1976) and northwestern Queensland (Kershaw 1975) indicates the onset of a period wetter than today. In the south at least, this was accompanied by a return of trees to channel margins. Thus it represents the initiation of hydrologic and vegetational environments rather similar to those of today. Under these conditions the ancient channels proved too inefficient to carry waters of the changed regime. It was such an inbalance between the requirements of the new hydrologic phase and the highly inefficient and sinuous system of the ancient form that helped bring about avulsion with the development of straighter channels possessing steeper gradients which more effectively transport the waters of the present regime.

The evidence presented here establishes the widespread influence of the glacial age hydrologic environments on catchments draining the summer rainfall area, a feature previously known only for the winter catchments. Moreover the evolution of glacial age channels and their progressive loss of efficiency has been a real factor in the formation of anabranches with younger more efficient channels breaking out to follow newer courses. Recently Woodyer, Taylor and Crook (in press) have described a model to explain anabranch development by progressive plugging of suspended load channels by deposition of clay. This mechanism involves no hydrologic change and in the area from which their evidence was drawn, the Namoi-Barwon rivers, it may be the single responsible mechanism. However, in the lower reaches of the Darling, anabranching was associated with hydrologic changes that accompanied the transition from late glacial to Holocene regimes.

CONCLUSIONS

The sections exposed in the pipeline trench demonstrate a sequence of landforms and sediments, each phase of which is related to climatically controlled events in a changing hydrologic environment.

About 30,000 B.P. active alluviation was occurring in the region north of the present Darling channel. This phase was followed about 20,000 B.P. by the onset of aeolian activity which produced new, and remoulded older, sand dunes throughout the region. Radiocarbon dates place the timing of this event between about 20,000 and 16,000 B.P., in excellent agreement with the age of maximum aeolian activity established elsewhere in southern Australia.

Simultaneously with the onset of dune building the Darling River, carrying discharge through the region from well-watered areas of southwestern Queensland, cut a new channel which ultimately evolved into the present course of Acres Billabong, a typical anabranch of the lower Darling system. The hydrologic regime of this phase produced rapid lateral migration of the channel, the size and shape of which was drastically different from that of the modern Darling. The morphologic relationships between the glacial age ancestral and modern channel in this region bear a striking similarity to those that existed between the modern and ancient Goulburn River in the winter rainfall regime further south. The similarity between ancestral rivers draining both summer and winter catchments is believed to be due to increased bedload regimes associated with increased peak discharges in systems flowing through areas of regionally high watertable. Stages of low flow with seasonal reversal of piezometric gradients resulting in a long period of groundwater return through the banks would help produce the high rates of bank failure necessary to explain channel migration rates of 20 cm/year for a duration of more than 7,000 years. Increased rate of bank failure and lateral enlargement of meanders may have been enhanced by flood-wave conditions more peaked than those of today, a condition favoured by stronger seasonality of glacial age climates.

The Acres system probably entered its waning phase about 13,000 B.P. having already achieved a highly sinuous, low gradient course. Soon after 11,000 B.P. avulsion occurred, the new channel leading to the development of the present Darling. This event may have been due to an increase in stream flow about that time, the Acres channel having become so inefficient that it proved incapable of accommodating the increased discharge. The similarity of both the ancestral anabranches and the modern channel downstream with those relationships established near Tilpa suggest that the causes of anabranching in the lower Darling are identical with those proposed from the pipeline section.

Finally, the synchroneity in age and similarity in form between aeolian and fluviatile landscapes of the Darling region, when compared with related forms in the winter rainfall region further south, demonstrate the ability of glacial age processes to produce similar features throughout widely differing climatic and physiographic regions, an ability that is even more remarkable in the light of the differences that exist between those regions today.

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